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R E P O R T

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## Learning from Experience

### The Public Health Response to West Nile Virus, SARS, Monkeypox, and Hepatitis A Outbreaks in the United States

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## SUMMARY

State and local public health systems play a critical role in responding to emergencies and are central to the nation's efforts to improve its preparedness for bioterrorism. But public health departments have faced some significant challenges over the years. During the last half of the 20th century, the capacity of state and local public health systems in the United States seriously declined. Problems in the systems—such as weaknesses in laboratory capacity and poor communications with the public and health care professionals—were vividly displayed during the anthrax attack in 2001.

In the aftermath of these events, Congress and the Department of Health and Human Services (HHS) accelerated efforts to strengthen the public health infrastructure. In the spring of 2002, approximately \$1.1 billion was distributed through the Office of Public Health Emergency Preparedness, the Centers for Disease Control and Prevention (CDC), and the Health Resources and Services Administration (HRSA) as part of cooperative agreements to strengthen state and local public health as well as hospital preparedness, with an additional \$2.9 billion provided to the states in 2003 and 2004 (Schuler, 2004). After three years of major federal investment, it is appropriate to take stock of the current state of preparedness in local and state public health departments.

Four recent disease outbreaks from 1999 to 2003 provide a rare opportunity to assess the quality of the public health response and to gain insights into overall preparedness for a bioterrorist attack. These outbreaks include Severe Acute Respiratory Syndrome (SARS), monkeypox, and hepatitis A in 2003, and West Nile virus. Taken together, the four outbreaks tested a wide range of public health capabilities.

### **THE PUBLIC HEALTH RESPONSE TO THE FOUR OUTBREAKS WAS ROBUST, BUT CHALLENGES REMAIN**

This report provides a focused assessment of public health's response to the four disease outbreaks in our case studies. It should be noted at the outset that, very fortunately, none of the outbreaks involved large numbers of human cases and deaths, substantial person-to-person transmission, or major social disruption. The outbreaks, however, did present three challenges that might also be presented by a bioterrorist attack. First, initial identification of the agent took

considerable time in three of the four outbreaks because the organisms causing them had not previously been seen in the United States. Second, in part because of the novelty of the biological agents, there was little information available about the clinical and epidemiological aspects of the diseases and about appropriate treatment and control strategies. Finally, due to limited resources and staffing, health departments found it difficult to both respond to the outbreak and perform their day-to-day operations. These challenges, therefore, provide us with a glimpse of how the public health system in the United States might respond to a major public health crisis such as one involving a bioterrorist attack or influenza pandemic.

In responding to these outbreaks, state and local public health agencies demonstrated their ability to implement all the major components of response to a public health emergency. Compared with what might have happened and to outbreaks in the past, the public health response to these outbreaks seems to have been fairly robust. The public health response was not without problems, however. We highlight here some of the key lessons learned from our evaluation of functional capabilities and capacity-building activities (explained more fully under “The Public Health Response”).

## **THE NATURE OF PUBLIC HEALTH EMERGENCIES CALLS FOR CORE CAPABILITIES IN KEY AREAS**

Taken as a whole, our case studies illustrate several key characteristics of public health emergencies involving infectious diseases that should to be emphasized in preparing for future emergencies.

- **Public health emergencies develop over time.** Unlike a natural disaster such as a hurricane or explosion, the outbreaks studied all played out over a period of months, or in the case of West Nile virus, years, and were characterized by substantial scientific uncertainty and confusion as the epidemiologic “facts” of the outbreak emerged. Public health departments must expect and plan for such similar emergencies in the future.
- **The required public health response is not necessarily proportional to the number of people actually exposed, infected or ill, or the number of deaths.** This is true in part because, as in the outbreaks we studied, necessary efforts to identify additional cases—active surveillance—are likely to result in many potential cases coming to the health department’s attention, including individuals who do not have the disease in question but are worried that they do. Extensive population-based prevention efforts, such as education campaigns, are necessary to prevent transmission to others and reduce

the health consequences. These demands stress the capacity of public health systems even when the actual number of cases is small.

- **Public health agencies, unlike some other emergency responders, do not have command and control authority over important resources—hospitals and health care providers—as well as other government agencies that are needed for an optimal public health response. Moreover, jurisdictional arrangements in public health can be complicated.** Public health departments must rely on a host of other individuals and organizations, including health care providers and emergency responders as well as colleagues in other public health agencies, to mount an effective response. While most of the needed resources would likely be willing to help in the course of a crisis, they need direction in how to communicate and coordinate effectively. Moreover, while state health departments have most of the necessary authority to deal with a public health emergency, these functions are carried out through a mix of state, regional, county, and city entities, each of which operates in relation to different political leadership structures and local governmental and community organizations. Matters are further complicated by the lack of respect that pathogens show for state and local geography—with outbreaks quickly spreading throughout states and across state lines.
- **State and local public health departments may be overly optimistic about the help that they can realistically receive from the CDC during a public health emergency.** During an emergency, CDC is also often looked to for scientific advice and other kinds of help, and in many instances this support is both essential to state and local health departments and effective. On the other hand, state and local health departments may not be realistic about the kind of support they can expect from CDC or the timeframe in which such support will be available.

Specific approaches for addressing these issues will vary depending on the particulars of the disease outbreak. However, certain core capabilities are clearly needed. These include well-developed surveillance systems, epidemiologic and laboratory investigations, and the ability to develop policies and procedures to implement population-based prevention and clinical treatment. These must be supported by effective communication and coordination among all key players involved in public health response, information technology to support these communications, appropriate workforce training and assurance of sustained competence,

participation in exercises and similar activities, and long-term planning to facilitate the development of partnerships and the clarification of lines of authority. CDC, together with state and local health departments, can learn from experience with such disease outbreaks as the ones we are studying to determine how it can best support state and local public health agencies, and then set and communicate realistic expectations.

## THE PUBLIC HEALTH RESPONSE

We examined the public health response to these outbreaks in terms of the “capacity-building activities” and “functional capabilities” shown in Figure S.1. Capacity-building activities refer to actions taken to prepare for and enable an effective response to a public health emergency, while functional capabilities refer to those actions taken during the emergency itself. Both kinds of activities support the major objectives of early outbreak detection, effective response, and recovery and return to normal function, as well as the overarching goal of mitigating mortality, morbidity, stress, and social consequences of a terrorist attack or other public health emergency.

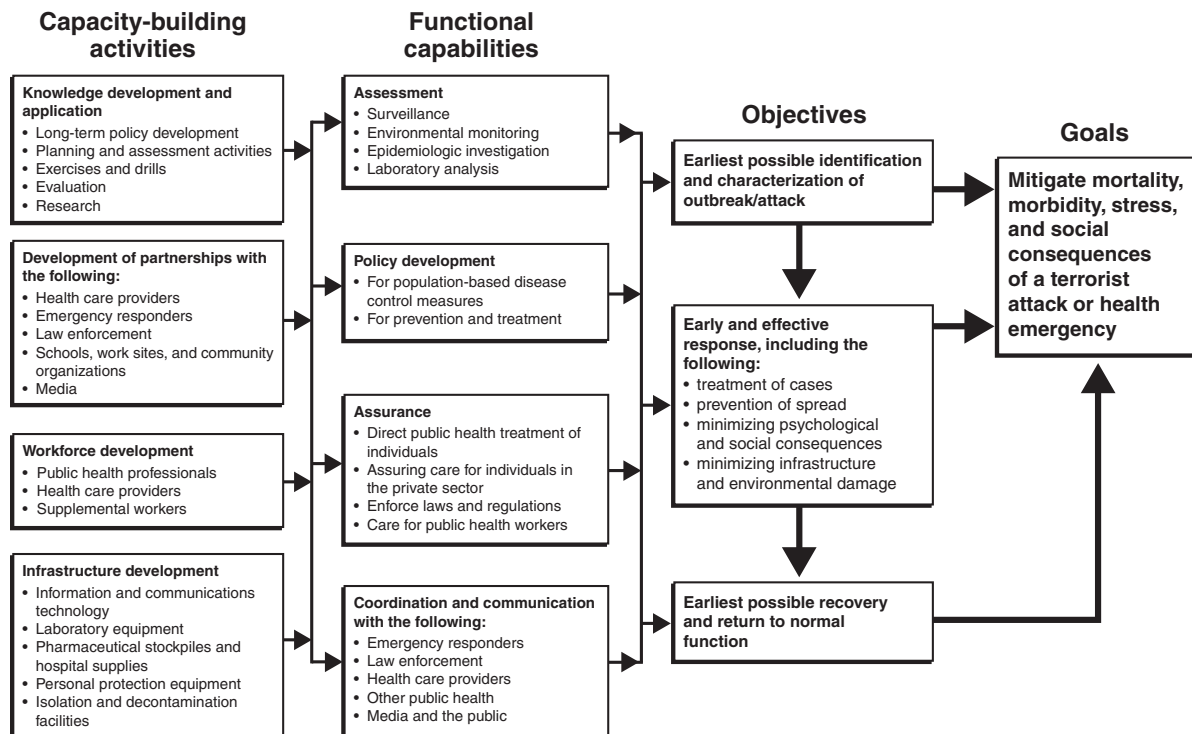


Figure S.1. A Logic Model for Public Health Preparedness Functional Capabilities

## **Public Health Assessment**

The case studies suggest that state and local health departments are able to use existing surveillance systems, or create new ones as needed, to detect and manage the outbreaks of the sort we studied. Health departments were able to detect and characterize West Nile virus and monkeypox, both of which were new to the United States. Public health agencies also effectively monitored West Nile virus as it spread across the country, SARS after it emerged in Asia, and hepatitis A, a relatively common food-borne disease. Our case studies show, however, that identifying and characterizing an outbreak is inherently difficult and slow when the number of cases is small (but has the potential to grow). The outbreaks highlight the importance of routine reporting of all suspect cases of a disease as well as the need for effective partnerships among public health departments and with health care providers, veterinarians, and others who can assist in the process of identifying and addressing a disease outbreak.

It was also clear that the public health system was severely stressed and sometimes overloaded by the response. For some outbreaks, such as West Nile virus and monkeypox, identifying the pathogen took weeks. Although public health departments demonstrated a basic ability to carry out epidemiological investigations, this process was often uncoordinated, with multiple investigations going on simultaneously. Such problems highlight the need to trace confirmed and potential cases as well as possible contacts. The development, in advance of any future outbreaks, of generic databases that can be adapted to the specifics of a given outbreak would likely improve the public health response in the future. Further, regional epidemiology offices within states would help to avoid the multiple simultaneous but uncoordinated epidemiologic investigations that occurred in the outbreaks we studied. In addition, overlap across state lines and with CDC, the Food and Drug Administration (FDA), or other federal investigations should also be addressed. Finally, state and local public health laboratories should build capacity and develop methods to handle the surge of samples they receive during outbreaks such as these, without compromising their ability to perform routine testing in a timely manner.

## **Just-in-Time Policy Development**

The SARS and monkeypox outbreaks raised awareness throughout the United States about the issues involved with implementing isolation and quarantine policies, but because the number of cases was relatively small they did not test these policies on a large scale. Significant

problems did arise, however, regarding enforcement, reimbursing health care workers for lost work time, when orders should be lifted, and so on. It seems likely that if many more individuals had needed to be quarantined or isolated, the public health system would not have been able to perform as required.

Each outbreak also tested the ability of health departments to develop, disseminate, and update evolving clinical policies in real time. While health departments were usually able to get the word out, there was often confusion about recommended policies for hospital infection control, clinical testing, and vaccination. During the West Nile outbreak in Louisiana, for instance, there was confusion about interpretation of clinical tests, and screening tests were considered confirmatory.

Some states had not reviewed and updated laws governing isolation and quarantine for almost a century, and some health officials were not sure what authority they had. Moreover, even in states where laws had been updated and clarified, little attention has been paid to implementation details including coordinating in advance with police and determining who would be called upon to enforce these policies; as a result, health officials could not be sure that their authority would be enforced. Such policies can help to clarify lines of authority for enforcing policies, eliminating ambiguities in policies, and other problems.

In general, health departments were able to develop policies for mosquito spraying and other control strategies with the help of experts from other government agencies, universities, and the private sector. However, public health had not dealt with such an intervention in years. These decisions were further complicated by the need to consider the health risks and environmental consequences of spraying, and varying public attitudes about these matters.

### **Communication with the Public**

The West Nile virus, SARS, monkeypox, and hepatitis A outbreaks provided an opportunity to review and revise public health departments' policies for communicating with the public and the media about public health risks. Improved communications with the public and the media yielded significant benefits to public health departments, as, for example, several public health officials indicated that their department's visibility increased during the West Nile virus outbreak and that the public and the media developed a better understanding of public health and its role in emergencies.

Public health was challenged in some cases when the need to raise awareness about one risk (e.g., the role of mosquitoes in spreading West Nile virus) led to concerns about another risk (e.g., potential harm from the use of insecticides to control the mosquito population). Furthermore, public health officials recognized that motivating behavior change among the public can be difficult even with a well-designed communications campaign.

Public health stressed the need for consistent communications, and also made efforts to target some communications to persons at heightened risk and to minorities and vulnerable populations. During the SARS outbreak, for instance, one local health department in New York worked with universities and high tech companies to reach their Asian employees and others who traveled frequently to Asia. In California, a mosquito control district developed special pamphlets, posters, magnets and other items in multiple languages that were specifically targeted to the large migrant worker community at risk for West Nile virus. In other cases, public health departments attempted to identify institutions that might have access to and credibility with minorities, migrant workers, rural and poor populations and other such groups.

Challenges remained. During the West Nile virus outbreak in Louisiana, for instance, public health agencies had difficulty communicating with and educating the African-American community because of the false impression that West Nile virus was “a white man’s disease.” In California, language and cultural barriers resulted in poor communication between the public health department and the Asian population about SARS. The outbreaks also underscored the need for “surge capacity” to meet the needs of hard-to-reach populations and to address high demand for information from the public.

Working with the media was an ongoing challenge. Health officials emphasized the need for public health to “speak with one voice” and to designate spokespersons and provide training to key staff to prepare them for working with the media. Establishing relationships with the media in advance, and working to anticipate their needs and to provide information that works within their constraints, is important to using the press as a tool to reach the public at large.

### **Coordination and Communication Within Public Health and With Its Community Partners**

Our case studies identified the need for strong communication and coordination between public health and other governmental agencies involved in emergency response. They also identified the need for public health to communicate and coordinate their activities with health

care providers and other professionals, such as veterinarians, to detect and characterize outbreaks, as well as to effectively treat patients and prevent further infections. Ensuring communication and coordination with all of the relevant parties is complicated for several reasons.

First, public health agencies, unlike some other emergency responders, do not have command and control authority over important resources—hospitals and health care providers—as well as other government agencies that are needed for an optimal public health response. While most of the needed resources would likely be willing to help in the course of a crisis, they must know how to communicate and coordinate effectively. Moreover, health care providers are needed to help with disease surveillance even before an outbreak comes to light; indeed, the information they provide is a key part of outbreak identification. Communication with health care providers is especially important when the “facts” of a disease outbreak are changing quickly.

Second, as the case studies illustrate, jurisdictional and legal arrangements in public health are frequently complex. State health departments have most of the necessary authority to deal with a public health emergency, but these functions are carried out through a mix of state, regional, county, and city entities, each of which operates in relation to different political leadership structures and local governmental and community organizations. In addition, many look to CDC for scientific advice and other kinds of help. Matters are further complicated by the lack of respect that pathogens show for state and local geography—with outbreaks quickly spreading throughout states and across state lines. As a result, there is likely to be uncertainty over which agency is responsible for what actions, both within and across state lines and with CDC. Appropriate roles can to some extent be worked out in advance through careful regional and state planning, but even so there will always be additional matters that need to be resolved during an emergency.

## **CAPACITY-BUILDING ACTIVITIES**

### **Knowledge Development: Organizational Learning**

State and local health departments in the United States have implemented a variety of activities aimed at enhancing knowledge within their agencies, as well as in the broader community public health system, about public health preparedness. The most common activities appear to be reviewing public health legal authorities, conducting exercises and drills, and implementing other educational opportunities for public health professionals. The process of meeting with first responders and other partners to refine plans seems to have aided communication and to have enhanced knowledge of each community partner's role in emergency preparedness.

Exercises and drills are relatively new additions to the public health knowledge development toolbox. Many health departments are now using them to assess gaps in preparedness plans, enhance capacities, and strengthen relationships with community partners. Although health officials generally voiced wholehearted enthusiasm for the usefulness of these exercises, efforts to evaluate outcomes and cost-effectiveness are in their infancy. Other challenges remain. Most important, key members of the public health response community, including community representatives and laboratory employees, were often not included in exercises.

State and local health departments appear to understand the value of learning from experience as a means of enhancing preparedness for responding to future events. Many public health departments considered their experience in responding to different disease outbreaks and other emergencies as an opportunity for ongoing learning. A number of the states that we visited issued planning or guidance reports that incorporate state and local health departments' experience with West Nile virus, and these proved useful to other states as the outbreak moved westward across the country. A few departments also summarized their experience for publication in the professional literature. However, given the workload of public health departments on a typical day—much less during an emergency situation—there is only limited time for reflection, synthesis, and application of lessons learned for plans for future events, and few models exist for doing so. In addition, we saw very few examples of health departments' use

of a formal continuous quality improvement approach or formal after-action reports, which can add consistency and thoroughness to the process of understanding and responding to lessons learned.

### **Workforce Development**

Federal funding has helped to increase the number of disease response staff, laboratory personnel, and communications staff in several states and it also helped to fund training in all of these areas. Clearly, the increase in staff and training helped health departments to conduct investigations, collect data, coordinate prevention and control measures, and respond to the media and the public during the West Nile virus, SARS, monkeypox, and hepatitis A outbreaks.

Despite this infusion of resources, the supply of many types of public health professionals—especially epidemiologists and public health laboratorians—is currently inadequate. Although some state and local health departments have been able to hire additional staff using federal funds, others reported that they are still understaffed and that a crisis would stretch them to the limit. Relatively low government salaries tend to make it challenging to attract and retain well-trained public health professionals. Personnel ceilings and hiring limits at the state and local levels (related to the financial crisis in state and local governments around the country) have made it difficult in some locations to hire new staff, even with new federal funds. In addition, a number of sites have hesitated to hire staff with federal funds—or have done so cautiously—because of concerns about supporting the position when CDC funding runs out.

Although federal funding has allowed for enhanced preparedness activities, it does not yet seem to have filled the vacuum related to general public health training for both public health professionals and public health partners. Indeed, interviewees in one local health department stated that they would like to see additional training opportunities in public health resources and responsibilities more generally.

### **Infrastructure Development: Laboratory Capacity and Information Technology**

Every state we visited has made and is continuing to make substantial improvements in laboratory capacity, increasing both the types and numbers of tests that can be performed. Most immediately, improved laboratory capacity has allowed many states to more efficiently perform tests for West Nile virus, as well as increase the number of labs capable of performing these tests.

Similarly, each state has upgraded its information technology infrastructure. The upgrades have ranged from purchasing cell phones to developing statewide electronic surveillance and notification systems. The simplest activity, supplying cell phones and pagers to public health employees, seems to have increased access to these personnel during outbreak situations. And while some electronic disease reporting and surveillance systems were still in development and thus their role was limited, others were used effectively during the outbreaks we studied. State and local Health Alert Networks have increased communications to state and local health departments, and to a lesser degree to providers, but limitations in the timeliness of the information and penetration into the health care provider community still limit their usefulness. Nonetheless, these were considered positive enhancements by the local public health officials. CDC's electronic, web-based communications tool, Epi-X, also seemed to have helped public health officials who used it keep abreast on events going on around the nation during outbreaks.

Recognizing the limitations of case studies to evaluate the impact of such interventions, we found many examples in which surveillance systems, increased laboratory capacity, information technology, telephone hotlines and other systems have been developed and used in a way that appears to have enhanced the public health response to the outbreaks studied. It should be remembered, however, that investments in systems of this sort are useful only to the extent that well-trained staff are available to use them effectively.

## **PUBLIC HEALTH DEPARTMENTS HAVE BENEFITED FROM FEDERAL FUNDING AND GUIDANCE**

In the years since 9/11, and to a more limited extent before then, the federal government has invested substantial resources in public health preparedness at the state and local level. While the impact of this funding is difficult to measure, the case studies provide many examples in which surveillance systems, increased laboratory capacity, information technology, telephone hotlines, and other systems have been developed and used in a way that appears to have enhanced the public health response to the outbreaks studied. Similarly, state and local health departments report on the positive impact during these outbreaks of additional staff who have been hired, regional epidemiological teams that have been deployed, and so on. The case studies suggest that the required planning and assessment activities have generally also made a positive difference.

Two alternative approaches to evaluating preparedness that might be considered are based on observing a state’s public health system’s performance (a) during actual public health emergencies similar to those reported here, and (b) in simulated situations such as tabletop exercises. In either case, an after-action report that summarizes observed strengths and weaknesses would have to be prepared. Perhaps more importantly, look-back and tabletop exercises should be imbedded in a quality improvement (QI) process that includes a mechanism to translate what is learned into organizational change.

Beyond this, the case studies also shed some light on the guidance associated with the CDC cooperative agreements, particularly the Focus Areas and Critical Capacities (CC). These measures were developed in part to measure progress that the states were making toward preparedness goals and to ensure accountability for federal funds. Table S.1 presents a summary of our assessment in these terms, highlighting areas in which selected Critical Capacities seemed to provide reasonably reliable measures of public health capacity as evidenced in the four disease outbreaks. Critical Benchmarks are addressed within the body of the report. Focus Area D (Laboratory Capacity—Chemical Agents) was not included in the CDC cooperative agreements since 9/11 and is not addressed here.

**Table S.1. Overview of CDC Focus Areas and Critical Capacities**

Relevant Focus Area	Comments
<b>Focus Area A: Preparedness Planning and Readiness Assessment</b>	<ul style="list-style-type: none"> <li>• Case studies reinforce need for “strategic leadership, direction, coordination, and assessment of activities” to ensure preparedness and interagency collaboration (CC #1) and “integrated assessments of public health systems capabilities” (CC #2). They also provide indirect evidence that these capabilities have made a difference in the outbreaks studied.</li> <li>• States were able to respond to public health emergencies (CC #3) with some degree of efficacy.</li> </ul>
<b>Focus Area B: Surveillance and Epidemiology Capacity</b>	<ul style="list-style-type: none"> <li>• Significant progress has been made toward development of real-time electronic disease reporting systems (CC #5), though it is unclear whether adequate training has been offered to ensure that providers know how to use these systems. In addition, veterinarians and other health professionals are generally not included in such systems.</li> <li>• Substantial progress has been made toward development of comprehensive epidemiology response systems (CC #6). This included hiring and training public health staff, setting up regional epidemiology offices, but generally not developing lists of private sector health care providers as suggested by the critical capacities and benchmarks.</li> <li>• We are also aware of only a few formal after-action analyses of natural disease outbreaks, despite the call for them in CC #7.</li> </ul>

<b>Focus Area C: Laboratory Capacity— Biologic Agents</b>	<ul style="list-style-type: none"> <li>• A continuing need exists for better coordination of lab services, the focus of CC #8.</li> <li>• Relevant to CC #9, the case studies demonstrate the importance of “adequate and secure laboratory facilities, reagents, and equipment to rapidly detect and correctly identify biological agents” for natural pathogens.</li> </ul>
<b>Focus Area E: Health Alert Network/ Communications and Information Technology</b>	<ul style="list-style-type: none"> <li>• Health Alert Networks (CC#11) have been developed extensively at the state level and to a lesser extent at the local level. Coverage of private health care providers in these systems, however, is still very limited in many places.</li> <li>• CC #12 through 14 relate to IT connectivity, which was not directly assessed, although our site visits suggested that progress is being made in this area.</li> </ul>
<b>Focus Area F: Risk Communication and Health Information Dissemination/Public Information and Communication</b>	<ul style="list-style-type: none"> <li>• Relevant to CC#15, our case studies identified various weaknesses in risk communication, including some that have been remedied, in part, with CDC funding. We also saw a considerable amount of learning from natural disease outbreaks.</li> <li>• The outbreaks emphasized the need for efforts to communicate effectively with special populations (Enhanced Capacity #11), and case studies indicate some progress in this area, but much more needs to be done.</li> </ul>
<b>Focus Area G: Education and Training</b>	<ul style="list-style-type: none"> <li>• Progress has been made toward ensuring the delivery of appropriate education and training to public health professionals and partners (CC#16), although the depth and breadth varies.</li> </ul>

Our assessment also identified areas that seemed important to public health preparedness that are not dealt with, at least directly, in the Critical Benchmarks and Critical Capacities. These include the following:

- **Quality improvement activities.** The importance of preparing formal after-action reports following major disease outbreaks, other public health emergencies, and exercises is recognized in Critical Capacity #7, but the value of this practice goes beyond surveillance and epidemiology (Focus Area B). As we discuss in Chapter 7, encouraging such reports could go a long way toward making state and local health departments into learning organizations that capitalize on experience to improve their capabilities.
- **Leadership.** *Leadership* and the *ability to respond to public health emergencies* are mentioned in Critical Capacities #1 and #3, and our case studies confirm the importance of these capacities (see especially Chapters 5 and 9). The related Critical Benchmarks are narrowly focused, however, and do not seem to be adequate measures of these concepts.
- **Communication and coordination.** As Chapter 5 illustrates, the ability of public agencies to communicate among themselves and with their partners, and to coordinate their activities, is critical during a public health emergency. Communication is covered in Critical Capacities #11 through #14, but these are primarily focused on information

technology rather than on the human connections and already formed partnerships that are vital to effective coordination. Similarly, Critical Capacity #3 addresses coordination in the form of planning activities, but whether the resulting plans translate into effective coordination during an emergency is not addressed.

- **Technology and effective public health systems.** Many of the Critical Capacities and Benchmarks focus on information technology, laboratory capacity, and related items without regard to whether public health systems can use this technology effectively in a public health emergency. As discussed in Chapters 7 and 8, some of the health departments we visited invested their federal funds in training existing and hiring new staff for key positions, whereas in others the ability to hire staff has been limited. Compounded with an aging public health workforce, technology alone will not guarantee the ability of health departments to respond to public health emergencies in the future.

## CONCLUSIONS

Taken together, four recent, relatively large-scale disease outbreaks in the United States—SARS, monkeypox, hepatitis A, and West Nile virus—tested a wide range of public health capabilities, providing a rare opportunity to assess the quality of the state and local public health response and to gain insights into the nation’s overall preparedness for public health emergencies, including a bioterrorist attack. Compared to outbreaks in the past, the public health response seems to have been fairly robust. Public health agencies demonstrated their ability to implement the major components of response to a public health emergency: assessment activities such as outbreak identification, epidemiological and laboratory investigation; population-based disease control activities such as vector control, vaccination and mass prophylaxis, and isolation and quarantine; providing advice to health care providers; communicating within public health, and with health care providers and other government agencies; and communicating with the public directly and through the media.

The public health response, however, was not without problems. Perhaps the most pervasive were communication difficulties within public health agencies and with public health partners, which impeded the public health response to each of the outbreaks. Some problems seem inevitable when dealing with a major/novel disease outbreak, and are likely to be worse for a bioterrorist attack. For newly emerging pathogens, for instance, the “facts” of the outbreak are

not clear at the outset, so additional time is needed to understand the epidemiological risk factors and develop effective control strategies. Many of these challenges would likely be more severe in a terrorist incident, and the implications of problems like those seen would be more severe. For other problems, the case studies provide examples of public health agencies learning and adapting during the outbreaks themselves. We saw relatively few instances, however, of more formal approaches to institutional learning. Failure to learn from actual emergencies, which are relatively rare, is a missed opportunity. One strategy that public health agencies can use to capitalize on these opportunities is to make it a practice to prepare after-action reports after major public health events.

On the whole, the case studies demonstrate how critically dependent success is on flawless performance of routine public health functions. In many parts of the country, however, these very capacities have declined, following a disinvestment in public health in the late 20th century. The case studies also demonstrate the need for strong communication and coordination between public health and other governmental agencies involved in emergency response, as well as effective leadership. The case studies also show the special need for communication and coordination with health care providers and other professionals, such as veterinarians, to detect and characterize outbreaks as well as to effectively treat patients and prevent further infections.